Developing Objective Drought Indicator Blends Using Principal Component Analysis

Tsegaye Tadesse, Ph.D.
Research Associate Professor,
Climatologist and Remote Sensing Expert,
Geospatial Coordinator
National Drought Mitigation Center (NDMC)
University of Nebraska-Lincoln, USA

2018 North American Drought Monitor Forum
Calgary, AB Canada, 1-3 May 2018

Acknowledgement

This work is supported by NDMC's USDA- and NOAA-funded projects

Research Team:

Tsegaye Tadesse, Geospatial Coordinator, NDMC

Mark Svoboda, Director, NDMC

Brian Fuchs, Monitoring Coordinator, NDMC, UNL

Yared Ashenafi, Research Scientist, NDMC, UNL

Getachew Berhan, Post-doctoral Researcher, NDMC, UNL

Chris Poulsen, GIS Manager, NDMC, UNL

John Swigart, Geospatial Analyst, NDMC, UNL

Jeff Nothwehr, GIS and Web Specialist, NDMC, UNL

Brian Wardlow, Director, CALMIT, UNL

Andualem Shiferaw, Graduate Research Assistant, NDMC, UNL

We would like to have collaborators from the drought community who are interested!!

Outline

1. Introduction: Objective Drought Indicator blend (ODI-blend)
   - Current method (NOAA-CPC)
   - PCA-based weighting
2. Current short- and long-term ODI blends
   - Data Inputs and historical maps with higher spatial resolution
3. Developing short- and long-term ODI blends using PCA
   - Data Inputs, Modeling, Evaluation, and Research Results
4. Summary and the way forward

Methods to Develop Objective Drought Indicators (ODI) Blends

Goal: Objectively combining/blending drought indices based on the potential contribution of each input variables to drought.

Methods of components weighting

1. Domain Expert judgment (NOAA-CPC's Experimental Objective Blends of Drought Indicators)
2. Weights based on statistical models: Principal Component Analysis (PCA)

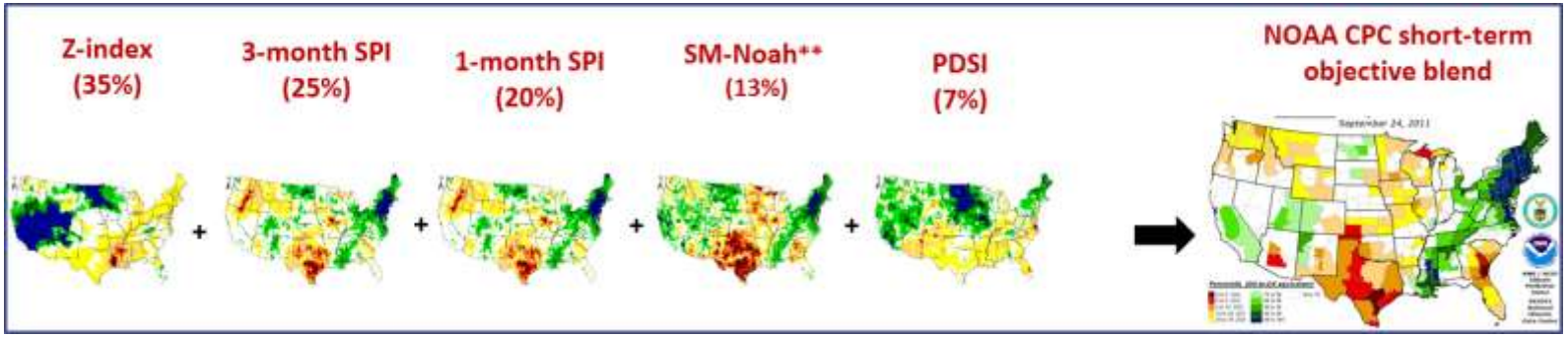
PCA-based USDM objective blend maps (PCA-based USDM)

- The main objective of this research is to provide an alternative objective weighting scheme (PCA approach) for the USDM blend maps and improve its spatial resolution.

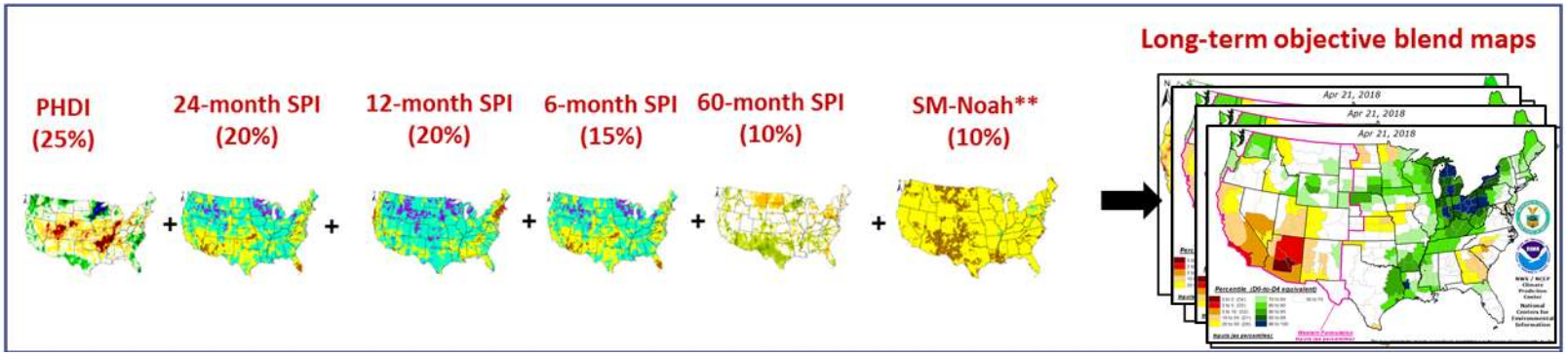
Current short- and long-term ODI blends

Weights are based on experts judgments

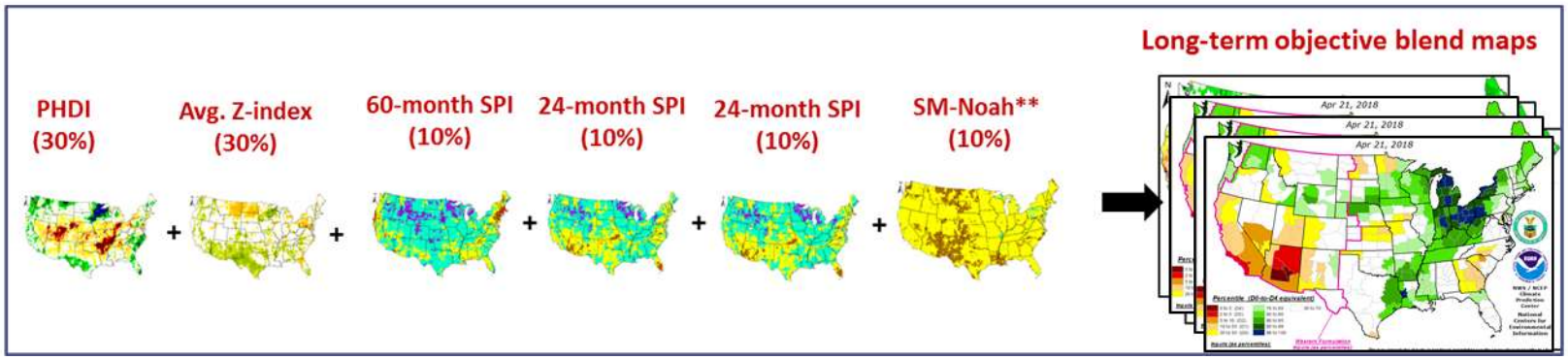
CONUS Short-ODI Experts' weight



Eastern US long-ODI Experts' weight



Western US long-ODI Experts' weight

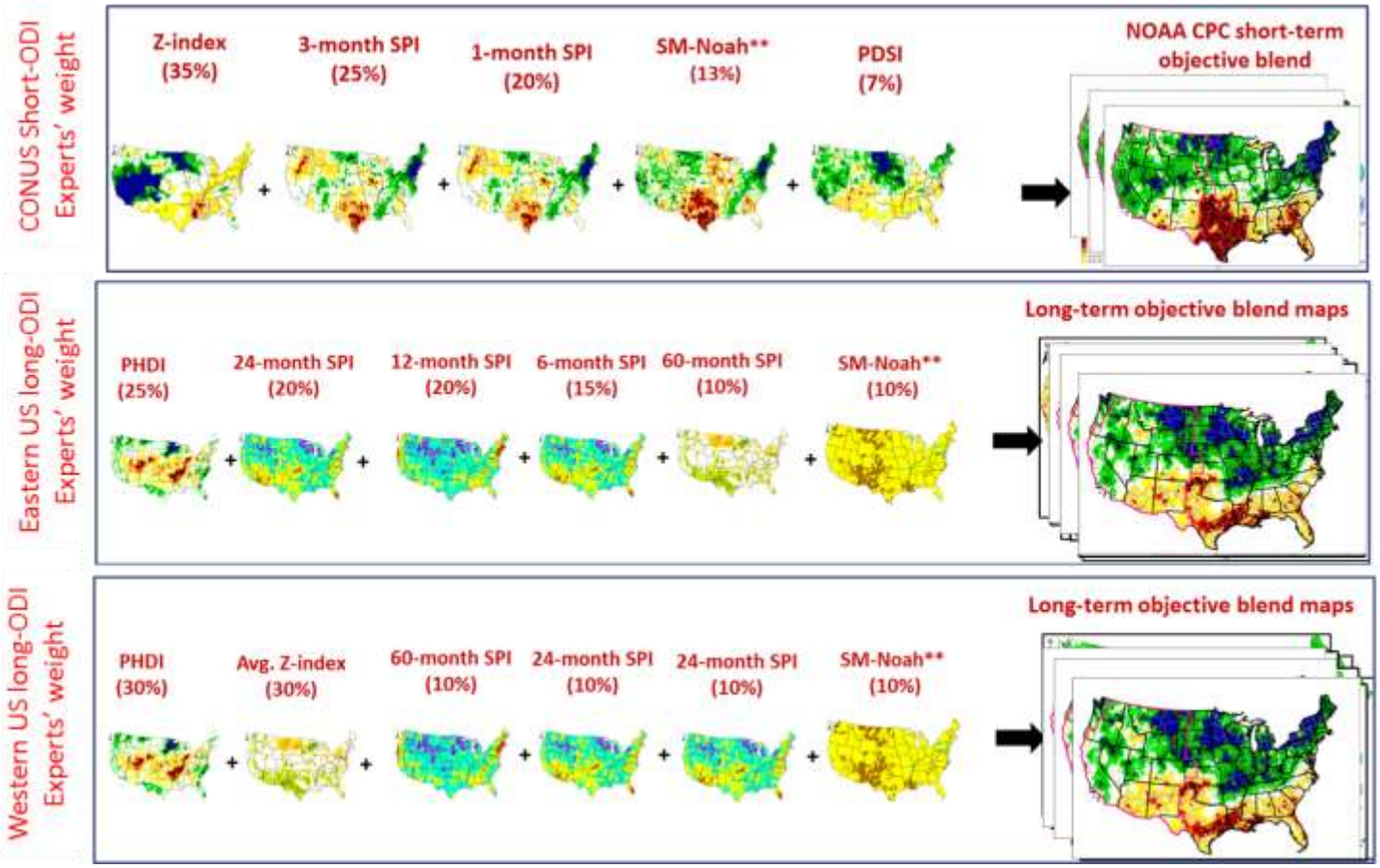


*These weights are drought experts' judgment inputs and weightings for the short- and long-term objective blend maps.
**NOAA used CPC soil moisture model. Because of data availability, we used NLDAS-Noah Soil moisture data.

Historical short- and long-term ODI blends

(based on expert judgments short-term objective blend)

**** NDMC produced historical ODI blend maps for the CONUS (1980-2012) at a higher resolution (~12.5 km)**

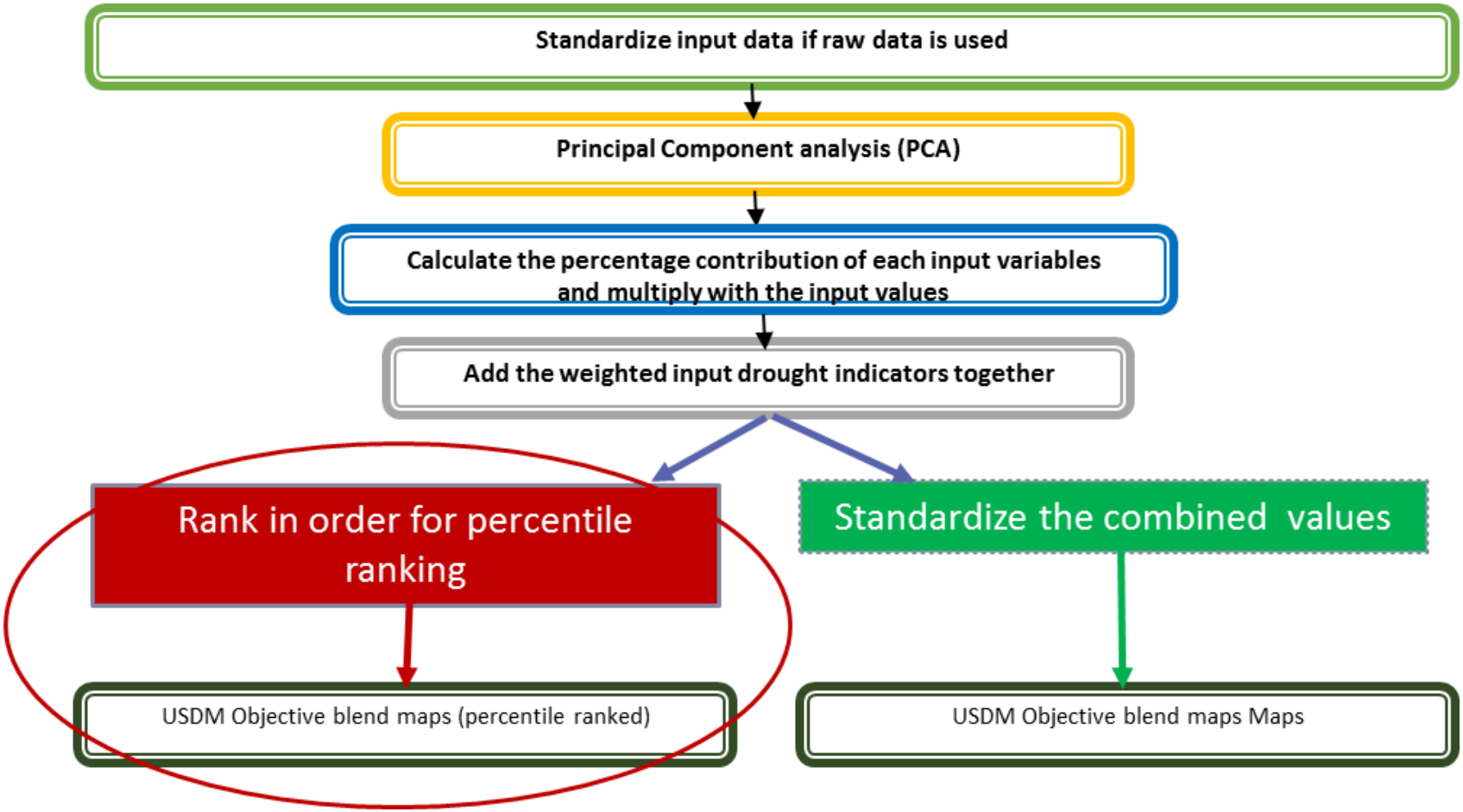


Expert-determined input components and weightings*:

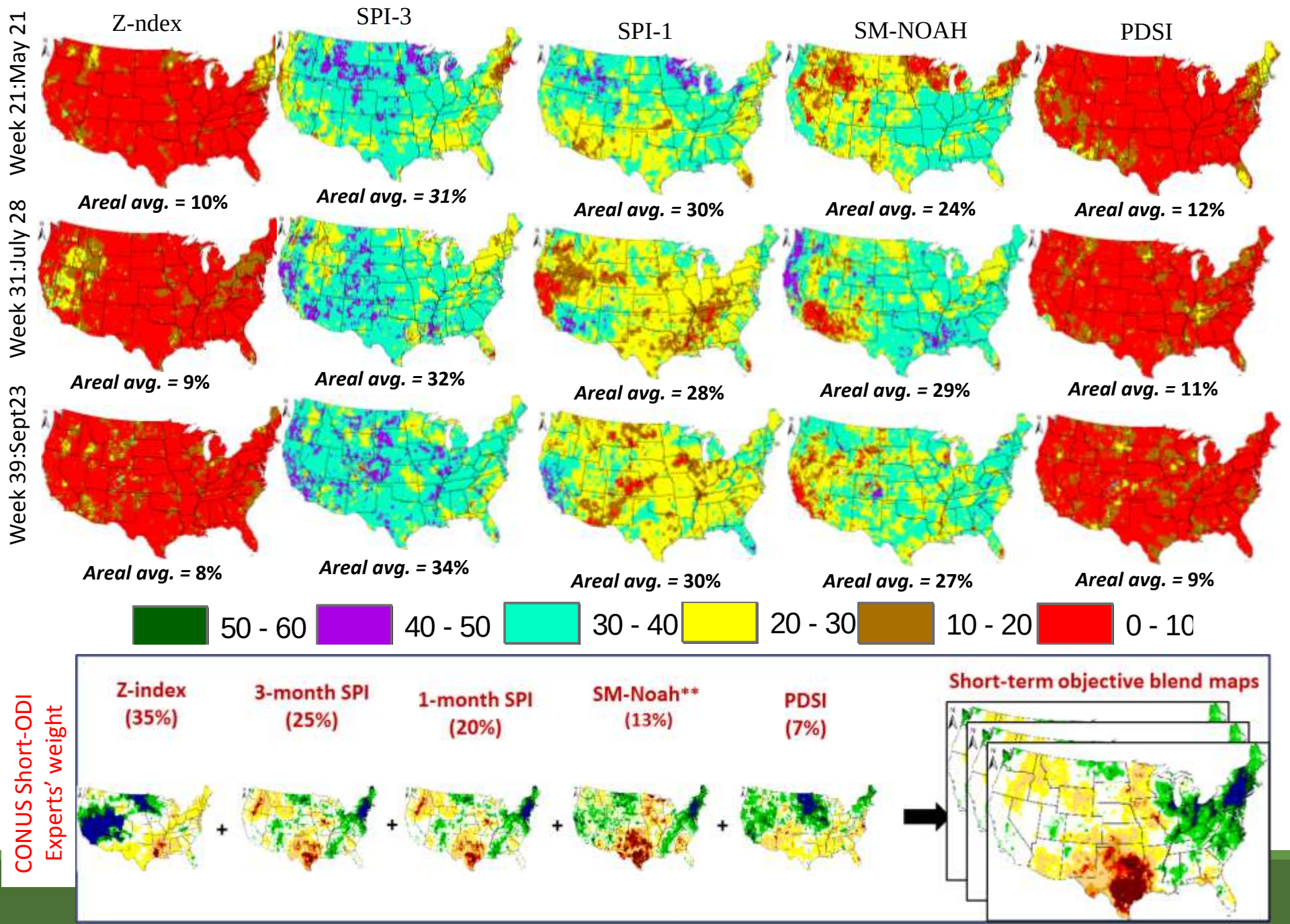
*These weights are drought experts' judgment inputs and weightings for the short- and long-term objective blend maps.
**NLDAS-Noah Soil moisture data.
*** Input maps in the fig. above are for illustration purpose only.

We have produced 3,432 historical (1980-2012) ODI blend maps similar to the NOAA-CPC climate-division blends, but at 12.5 km resolution.

PCA-based Combined Drought Indices (CDIs) Methodological Approach



PCA-based Percentage contributions of each input parameter for the short-term USDM blend



2011 Short-term Drought Indicator Blend

PCA- based objective blend

Expert judgement based ODI blend (standardized)

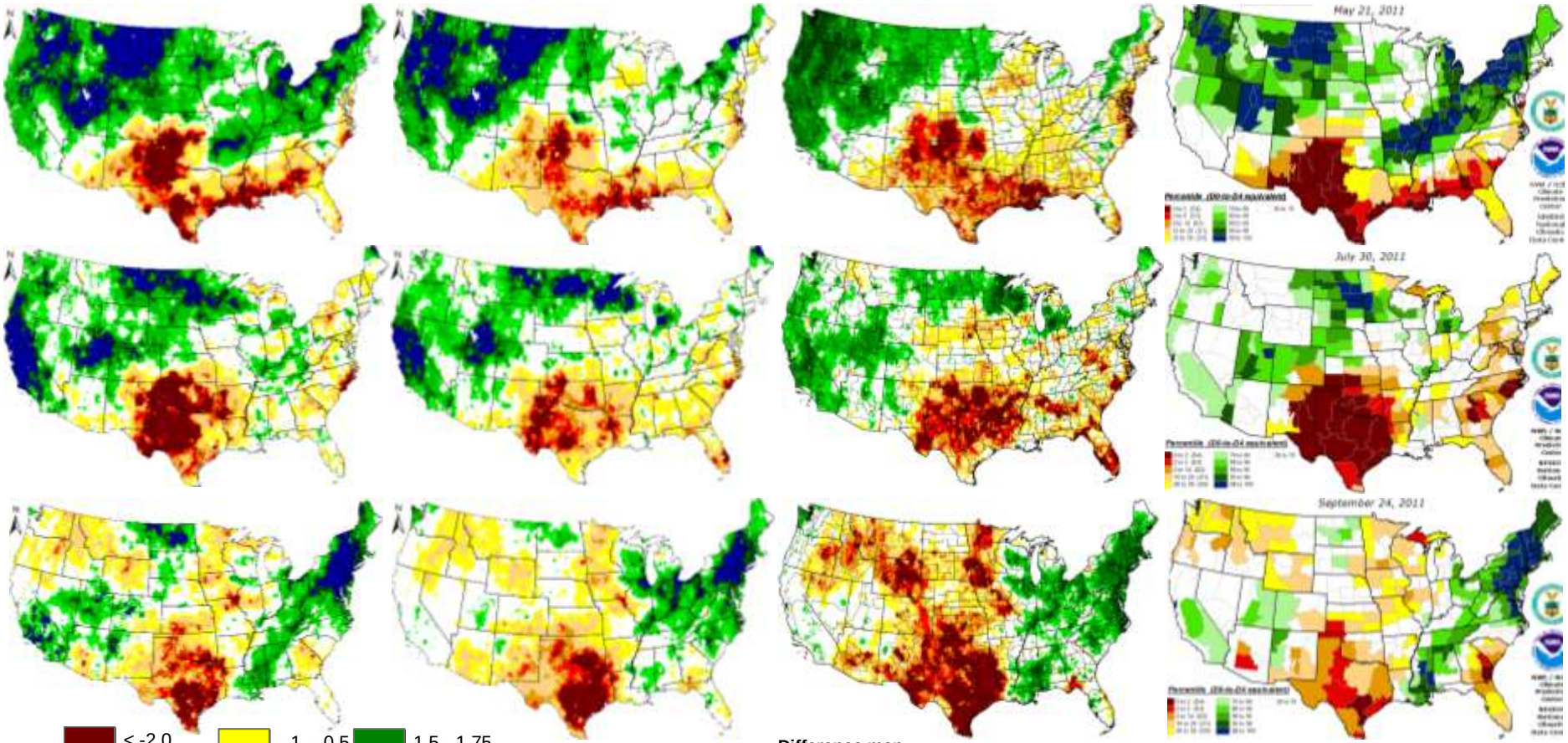
Expert judgement based ODI (percentile ranking)

NOAA Objective blend maps

Week 22 (May 21, 2011)

Week 31 (July 30, 2011)

Week 39 (Sep 24, 2011)



2012 Short-term Drought Indicator Blend

PCA- based objective blend

Expert judgement based ODI blend (standardized)

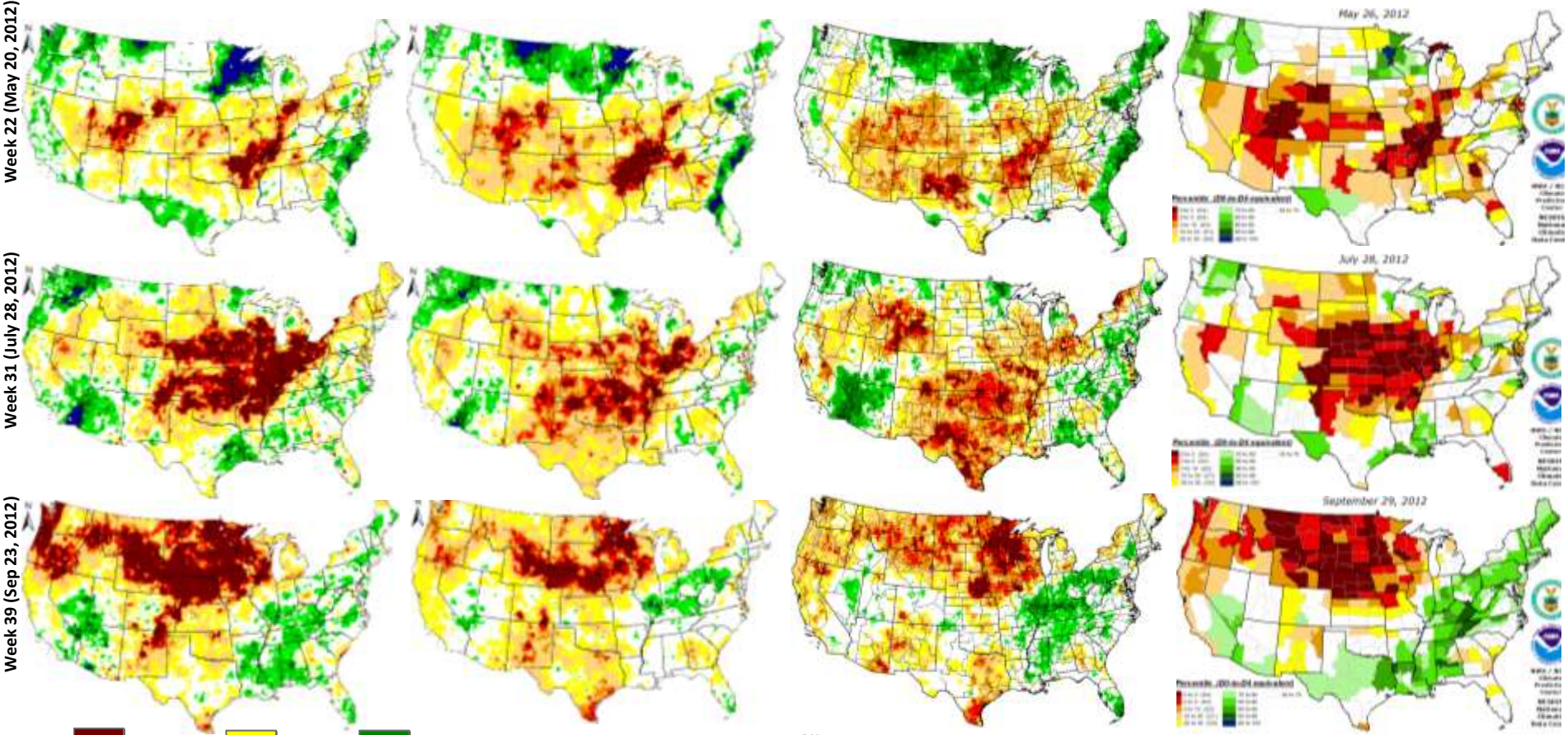
Expert judgement based ODI (percentile ranking)

NOAA Objective blend maps

Week 22 (May 20, 2012)

Week 31 (July 28, 2012)

Week 39 (Sep 23, 2012)

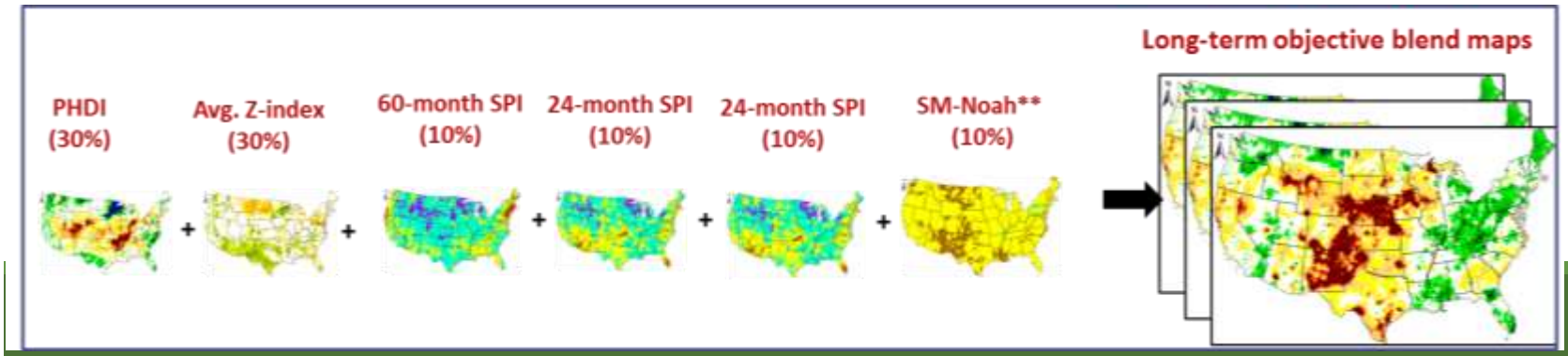


PCA-based Percentage contributions of each input parameter for the long-term Western US blend

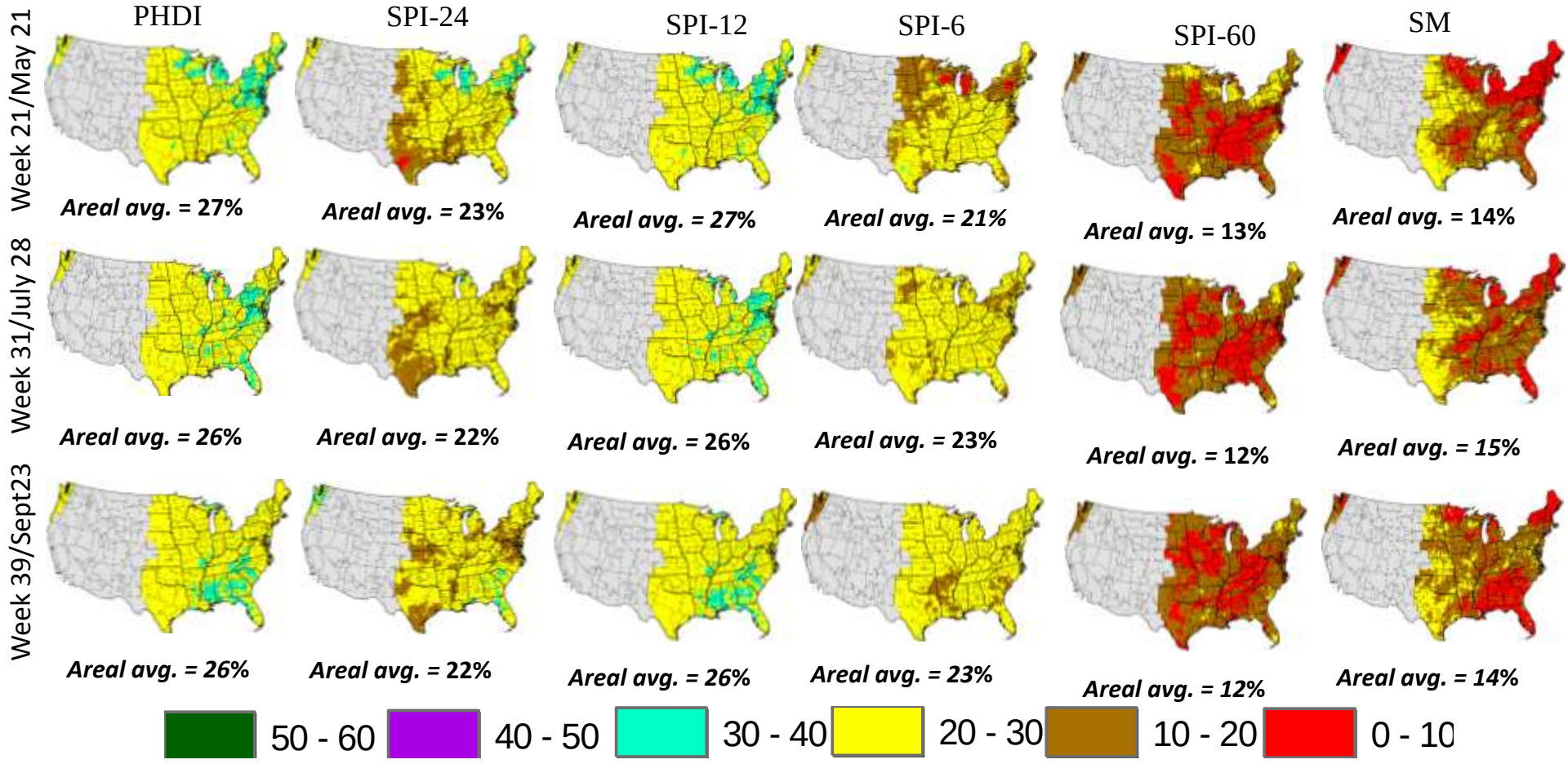
	PHDI	Avg. Z-index (60)	SPI-60	SPI-24	SPI-12	SM
Week 21:May 21	Areal avg. = 28%	Areal avg. = 14%	Areal avg. = 22%	Areal avg. = 24%	Areal avg. = 21%	Areal avg. = 16%
Week 31:July 28	Areal avg. = 20%	Areal avg. = 15%	Areal avg. = 23%	Areal avg. = 24%	Areal avg. = 20%	Areal avg. = 16%
Week 39:Sept23	Areal avg. = 20%	Areal avg. = 16%	Areal avg. = 23%	Areal avg. = 24%	Areal avg. = 20%	Areal avg. = 15%

50 - 60 | 40 - 50 | 30 - 40 | 20 - 30 | 10 - 20 | 0 - 10

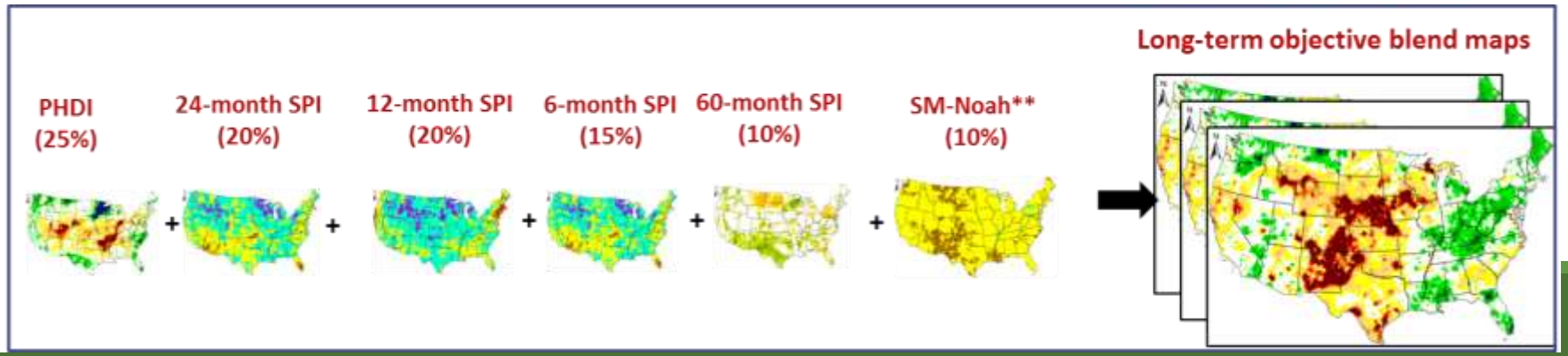
Western US blend Experts' weight



PCA-based Percentage contributions of each input parameter for the long-term Eastern* US blend



Eastern* US blend Experts' weight



2011 Long-term Drought Indicator Blend

PCA- based objective blend

Expert judgement based ODI blend (standardized)

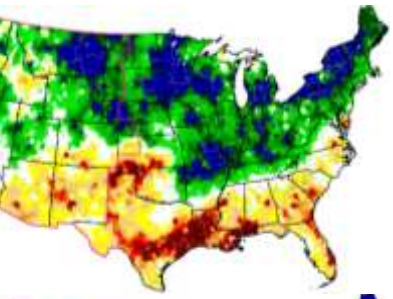
Expert judgement based ODI (percentile ranking)

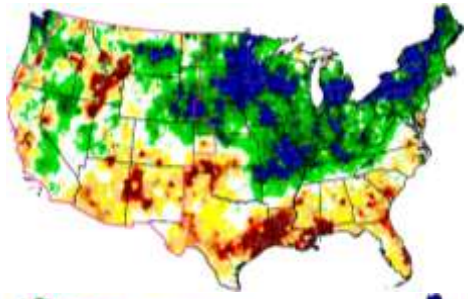
NOAA Objective blend maps

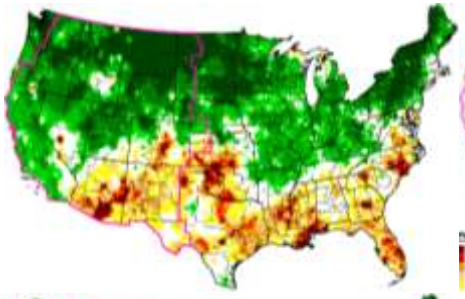
Week 22 (May 21, 2011)

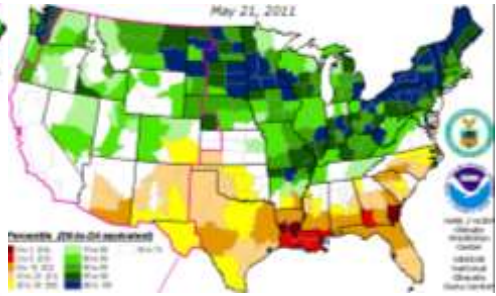
Week 31 (July 30, 2011)

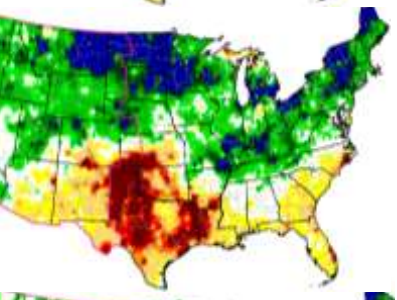
Week 39 (Sep 24, 2011)

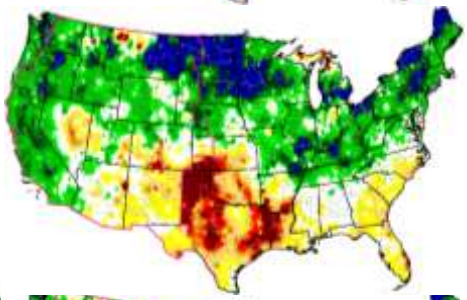


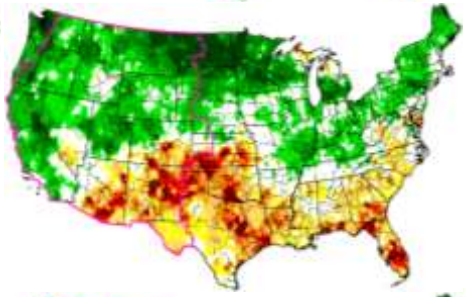


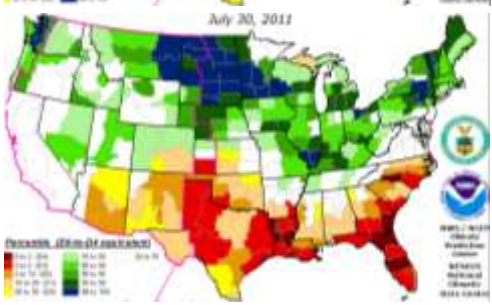


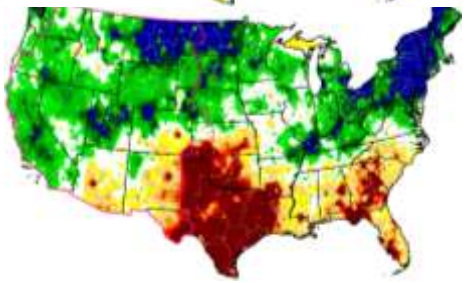


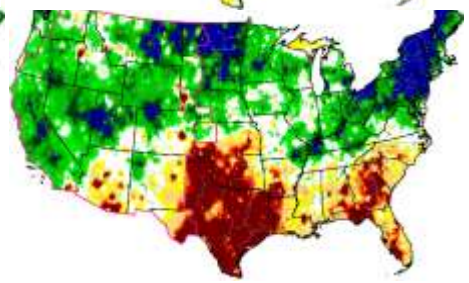


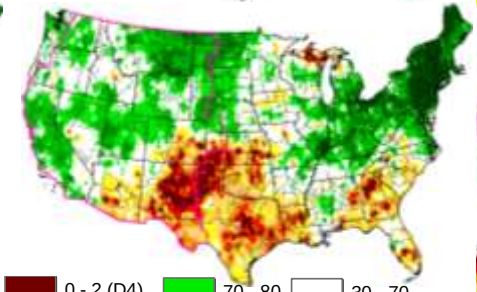


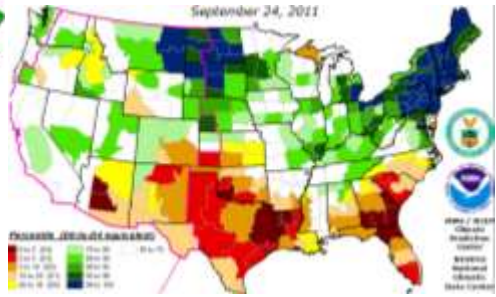












< -2.0
-2.0 - -1.75
-1.75 - -1.5
-1.5 - -1
--1 - -0.5
-0.5 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 1.75
1.75 - 2
> 2.0

0 - 2 (D4)
2 - 5 (D3)
5 - 10 (D2)
10 - 20 (D1)
20 - 30 (D0)
70 - 80
80 - 90
90 - 95
95 - 98
98 - 100
30 - 70

2012 Long-term Drought Indicator Blend

PCA- based objective blend

Expert judgement based ODI blend (standardized)

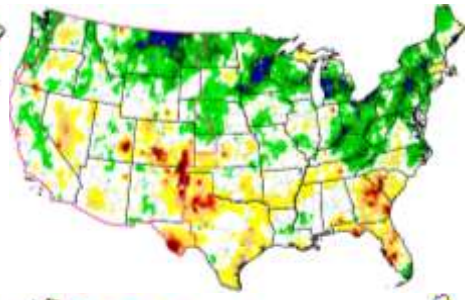
Expert judgement based ODI (percentile ranking)

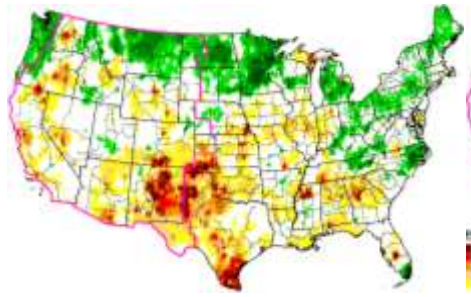
NOAA Objective blend maps

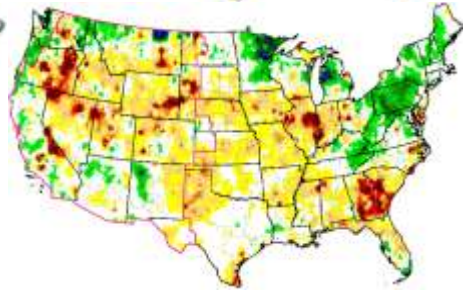
Week 22 (May 20, 2012)

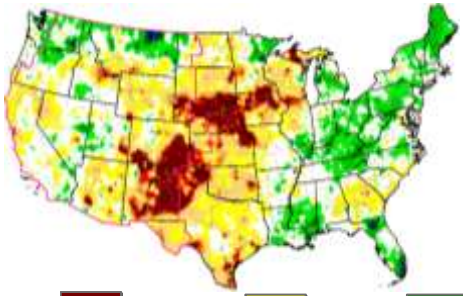
Week 31 (July 28, 2012)

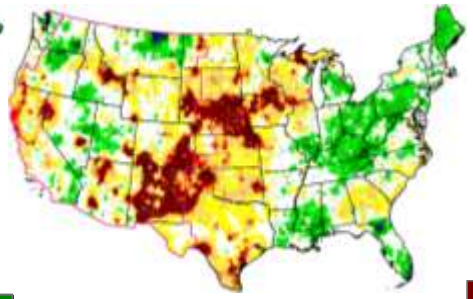
Week 39 (Sep 23, 2012)

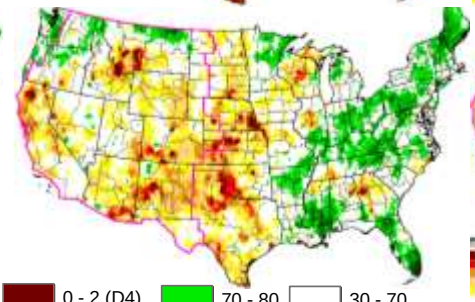












< -2.0
-2.0 - -1.75
-1.75 - -1.5
-1.5 - -1
--1 - -0.5
-0.5 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 1.75
1.75 - 2
> 2.0

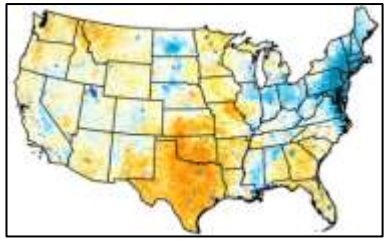
0 - 2 (D4)
2 - 5 (D3)
5 - 10 (D2)
10 - 20 (D1)
20 - 30 (D0)
70 - 80
80 - 90
90 - 95
95 - 98
98 - 100
30 - 70

Future works: blending more input data

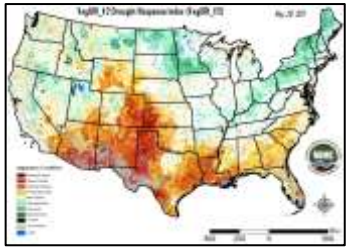
New input historical datasets for new blends maps may include:

- QuickDRI
- VegDRI
- ESI
- EDDI
- VPD
- GRACE

QuickDRI

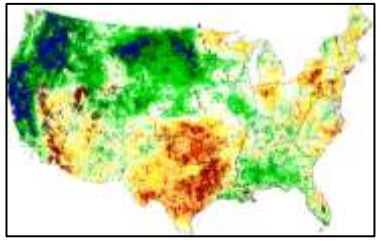


VegDRI

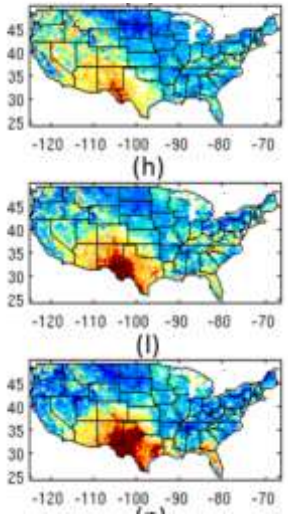


EDDI

ESI



VPD

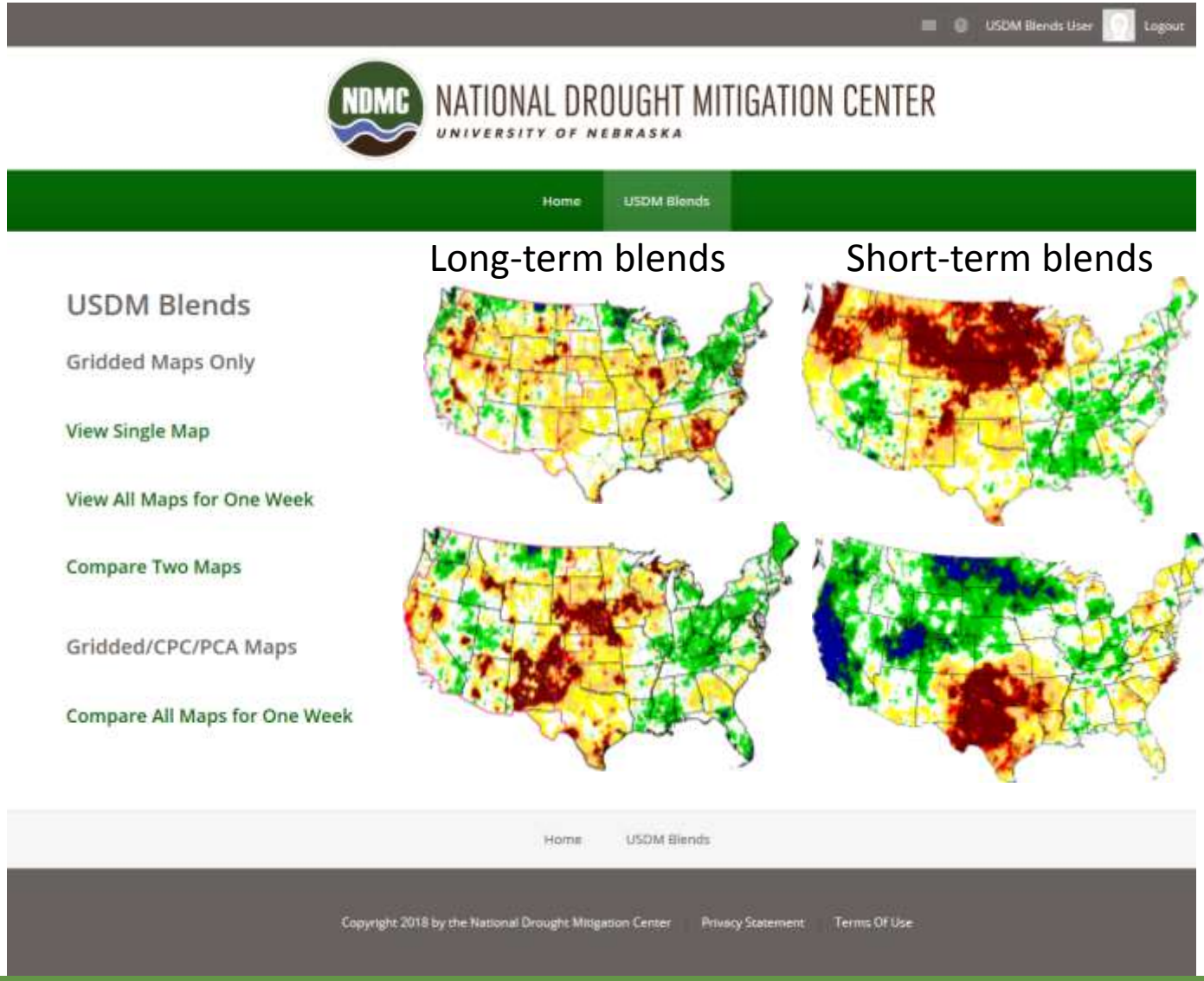


GRACE

- Short and long-term blends using:
  - longer time series data (1980-2017)
  - shorter time series (2003-2017)

USDM Blends at the NDMC website

(in development: http://dmcommunity.unl.edu/USDMBlends.aspx)



*Requires user name and password

Summary

- We've recreated blend maps and compared with the NOAA CPC's experimental blend maps (sanity check)
  - Assessed the blends using selected years (e.g., 2011 and 2012) in the growing season
    - Reasonably similar drought patterns and intensity observed
- Developed short- and long-term ODI blends using PCA weighting scheme
  - Avoids/limits the subjectivity of experts' judgment (though it's educated guess)
  - Improved the spatial resolution
  - New PCA-based blends preserve the seasonality of the climatic and/or growing periods
    - Each week in a year has a unique weights for the inputs as opposed to a "one-fits-all" weighting scheme
- We've produced historical short- and long-term ODI maps for CONUS (using both weighting schemes)
  - Short-term weekly ODI (1980-2012) – 3432 maps
  - Long-term weekly ODI (1980-2012) – 3432 maps
    - All blend maps do have higher resolution (i.e., 12.5 km vs climate division NOAA-CPC blends)
    - Are available at the NDMC website (but not publicly available yet)
- More evaluation with ground observation is needed
- We're exploring to include new input satellite-derived data and hybrid drought indices.

Thank You

Tsegaye Tadesse, Ph.D.
Research Associate Professor,
Climatologist and Remote Sensing Expert
Geospatial Science Coordinator
National Drought Mitigation Center (NDMC)
University of Nebraska-Lincoln, USA
Email: ttadesse2@unl.edu

DROUGHT.UNL.EDU e | ndmc@unl.edu /NationalDroughtMitigationCenter @droughtcenter